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(54) **Wall module for concrete wall**

(57) A method of constructing concrete reinforced structures employs a wall module (10) which includes a plurality of spaced, thin walled tubes (24) and a channel (12) along the upper edge thereof within which concrete may be received to respectively form vertical and horizontal structural supports. A plurality of spaced, vertical support studs (26, 28) disposed on opposite sides of the tubes (24) provide the module with sufficient compressive strength to carry the load of a floor mounted thereabove prior to filling the module with concrete. After the floor has been mounted on the wall modules (10), concrete is simultaneously poured into the tubes (24) and channel of the module as well as into the space between the module and the floor to provide a continuous concrete connection between the floor and the wall of the resulting structure.

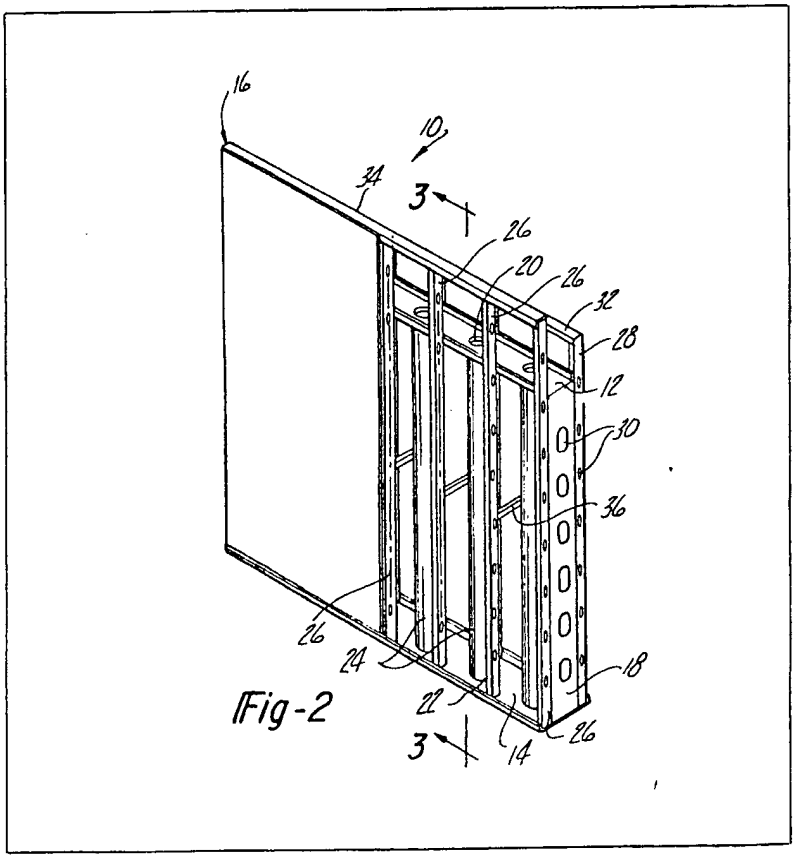

Fig-2

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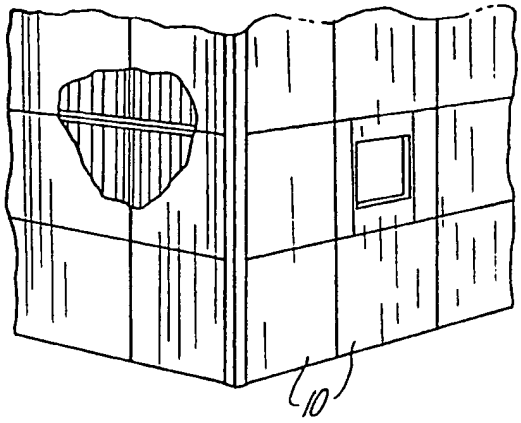

Fig-1

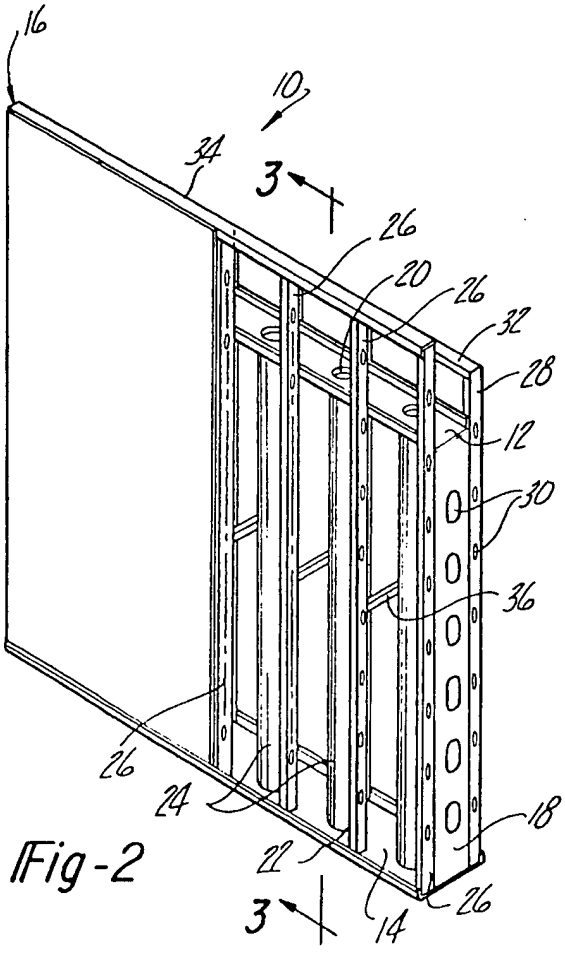

Fig-2

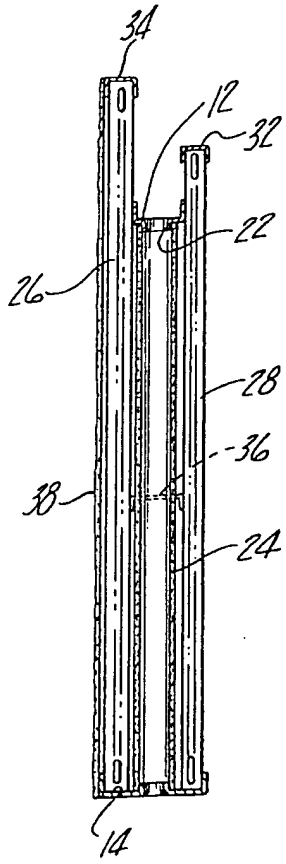

Fig-3

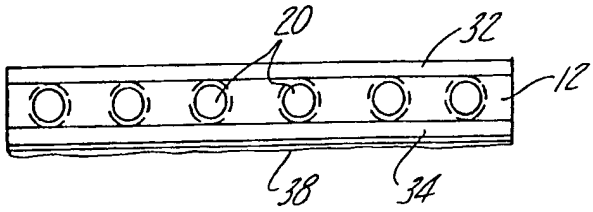

Fig-4

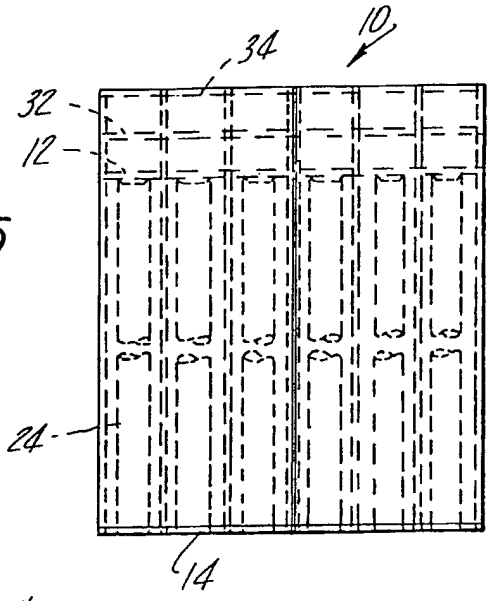

Fig-5

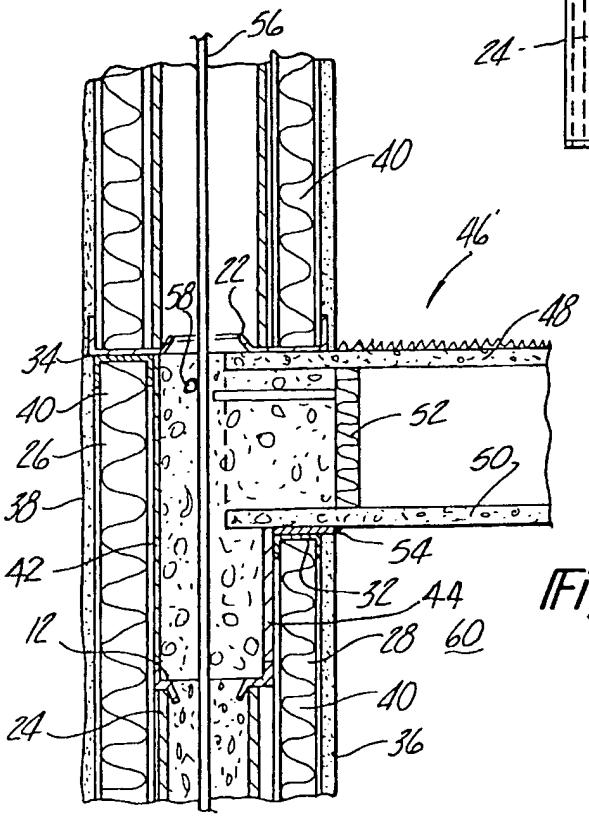

Fig-6

SPECIFICATION

Method of building construction using concrete reinforced wall modules and a module for use in said method

The present invention generally relates to prefabricated modules employed to construct buildings, and to a method of constructing buildings using modules of the type having voids therein to receive concrete.

The use of prefabricated building block components, such as wall modules having voids therein which are filled with concrete during the construction process, is well known in the art as evidenced by U.S. Patents 3,782,049 and 4,098,042. Prior art wall modules, such as those disclosed in the patents mentioned above, comprise a pair of spaced wall panels forming the inner and outer wall surfaces of the completed structure which have sandwiched therebetween a plurality of concrete forms in the nature of vertical tubes. The wall panels provide the module with a minimal degree of rigidity until the tubes are later filled with concrete.

These prior art wall modules are provided with an upper horizontally extending channel which is aligned with the channel of adjacent modules and forms a continuous concrete beam when concrete is poured therein when the wall is erected. In constructing a building using prior art modules, individual wall modules were first erected in place on a supporting surface and mechanically interconnected with each other. After steel reinforcement rods were inserted into the tubes, concrete was poured into the tubes and into a lower part of the channel portion of the modules up to the underside of a floor section which was later installed after the initial pour of concrete had cured. The initial pour of concrete formed a continuous concrete beam of partial height in the channel along the upper edge of the wall. It was then necessary to allow the first pour of concrete in the wall module to substantially cure in order to provide the modules with substantial structural strength, since the modules were otherwise too weak to support the loading imposed thereon by the floor thereabove.

After the concrete in the module had cured, a floor section was mounted on an upper edge of each wall module and additional reinforcement rods were inserted in the space between the floor section and the channel of the wall modules. Finally, a second pour of concrete was introduced into the space between the floor section and the channel of the wall modules to complete interconnection of the wall with the floor section. From the foregoing, it can be appreciated that two separate pours of concrete were required in erecting each wall and floor, with a substantial period of delay being necessary between each pour to allow the concrete to cure sufficiently to provide the necessary structural strength demanded by subsequent construction phases. Consequently, the use of prior art wall modules and method of construction were responsible for introducing a substantial construction delay, and was therefore somewhat undesirable in terms of construction economy.

Another problem related to the previous construction technique involved the fact that an essentially "cold" joint was formed between the floor section and the walls; this was because separate pours of concrete were required to form the various structure components comprising the connection between the floor and wall. These cold joints naturally reduced the strength and overall structural integrity of the resulting building. The prior art construction technique and wall module also necessitated the use of scaffolding and the like in order to gain access to the concrete receiving openings in the wall modules along the upper edge thereof, since a floor was not present, prior to filling the modules with concrete, upon which construction workers might be supported in a position to have the necessary access to the interior of the modules.

Still a further difficulty with the prior construction technique relates to the fact that each pour of concrete often required the use of heat applied thereto to aid in curing of the concrete during cold weather. Heretofore, it was necessary to direct a plurality of space heaters or the like against the module walls in order to warm the freshly poured concrete. However, since the floor above the wall being cured had not yet been installed, the area bounded by the walls was open to the environment and the majority of the heat directed onto the walls escaped into the surrounding cold environment. This not only resulted in incomplete or inconsistent curing of the concrete in the modules and increased the overall curing time, but resulted in a considerable waste of energy required to generate the heat.

An object of the present invention is to provide an improved method of constructing a structure in which the aforesaid difficulties are obviated or mitigated.

According to the present invention there is provided a wall module for use in building concrete structures, comprising:

a plurality of rigid elongate tubes disposed in spaced, parallel relationship to each other;

a first elongate frame member extending transverse to the longitudinal axes of said tubes and connected to one end of each of said tubes;

a second elongate frame member extending transverse to the longitudinal axes of said tubes and connected to the other end of each of said tubes; and

a plurality of vertical support members disposed in spaced, parallel relationship to each

other and each connected to said first and second frame members, said vertical support members being laterally spaced from said tubes and including portions extending beyond said one end of said tubes.

According to a further aspect of the present invention there is provided a method of constructing a cast-in-place concrete structure using prefabricated wall modules of the type having vertical voids and a horizontally extending channel along the top thereof, said voids and said channel being adapted to receive concrete therein, said structure further including a floor section having a horizontally extending space therein communicating with said module channel, comprising the steps of:

(A) erecting at least one of said wall modules;

(B) then, placing said floor section on top of an upper horizontal edge of said one wall module;

(C) supporting the weight of said floor section using said one wall module; and

(D) then, introducing flowable concrete substantially simultaneously into said vertical voids, said channel and said horizontally extending space whereby to form vertical concrete supports in said wall module and a continuous concrete connection between said wall module and said floor section.

The method of the invention preferably employs a wall module which includes a plurality of spaced, thin-walled tubes held in fixed relationship to each other by an upper and lower horizontal frame member. The module further includes a plurality of spaced, vertical support studs laterally positioned on opposite sides of the tube and connected to the upper and lower frame members in order to provide the module with sufficient compressive strength to carry the load of a floor mounted thereabove prior to filling the module with concrete. Upper portions of the module include an elongated channel communicating with each of the tubes and with a space within a floor section mounted thereon. Concrete is sumultaneously introduced into the tubes and the channel of the module as well as into the space between the channel and the floor section to form a continuous concrete connection between the floor and the wall using a single pour of concrete. Since the floor is installed above the walls before the concrete is poured, construction workers may stand on the floor to gain access to the channel of the modules for purposes of pouring the concrete. Moreover, the floor and walls form an enclosure which may be heated to thoroughly and uniformly cure the freshly poured concrete.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, and in which like reference numerals are employed to designate identical components in the various views:

Figure 1 is a perspective view of a corner of a building structure formed in accordance with the method of the present invention, with a wall section broken away in section to show details of the interior construction;

Figure 2 is a perspective view of one of the modules used in the method of the present invention, parts being broken away for clarity;

Figure 3 is a sectional view taken along line 3–3 in Fig. 2;

Figure 4 is a top plan view of the module shown in Fig. 2;

Figure 5 is a front elevational view of the module shown in Fig. 2; and

Figure 6 is a sectional view of a joint formed between a pair of the wall modules and a floor section.

Referring to the drawings, the present invention concerns a method of constructing concrete buildings using a plurality of interconnected wall modules 10. Although the modules 10 shown in the drawings are depicted as being suited for forming exterior walls of a building, it is to be understood that such modules are readily adapted for use as interior walls, as will become later apparent. Additionally, it is to be understood that the wall modules 10 of the present invention may be readily adapted to have windows or the like defined therein, similar to that described in U.S. Patent No. 4,098,042.

Each of the modules 10 includes an upper and lower horizontally extending, elongate frame member 12 and 14, respectively, which have joined thereto on opposite ends thereof, a pair of vertically extending end walls 16 and 18. Each of the upper and lower horizontal support members 12 and 14 is provided with a plurality of longitudinally spaced, circular apertures 20 therein, preferably formed by punching, which define inwardly turned, tube retaining flanges 22.

The module 10 has an inner core defined by a plurality of thin wall, hollow tubes 24 each of which has the opposite ends thereof essentially open to receive the flanges 22 therewithin. Typically the tubes 24 may be about 6 to 9 inches in inside diameter and may be formed of any self supporting material such as cardboard which has sufficient tensile strength to support the forces imposed thereon by concrete slurry poured within the tubes. The tubes 24 do not perform a structural function in the completed building structure, but rather only act as forms for the pouring of the concrete. In the case of a module intended for use as an exterior wall component, the tubes 24 may typically be disposed on 16 inch centers. The flanges 22 function to retain the tubes 24 between the horizontal support members 12 and 14 in aligned, parallel registration with each other and perpendicular to the upper and lower frame members 12 and 14.

A first set of vertical support members, in the nature of studs 26, each have one end thereof secured to the horizontal support member 14, while upper regions of the studs 26 are secured to the upper horizontal support 12. A second set of parallel vertical support members, or studs 28, also have one end thereof secured to the horizontal support members 14 while upper regions thereof are secured to upper horizontal support member 12. Studs 26 and 28 are disposed on opposite lateral sides of the tubes 24, in spaced relationship to the latter. Studs 26 and 28 are spaced alternately with respect to tubes 24, and may be typically disposed on 16 inch centers in the case of a module intended for exterior wall use. End walls 16 and 18 as well as studs 26 and 28 may be made of suitable metal stock and are preferably provided with lightening apertures 30 to reduce the overall weight of the module 10. As particularly shown in the drawings, the studs 26 and 28 are of U-shaped cross section and extend parallel to each other as well as to the tubes 24. Both studs 26 and 28 extend vertically above the horizontal support member 12, but studs 26 extend above the upper ends of studs 28 to form a floor receiving notch in the top of the interior side of module 10. The upper ends of studs 28 are each connected to a horizontally extending interior plate 32 which is preferably of U-shaped configuration. Similarly, the upper ends of each of studs 26 are connected with each other by a horizontally extending, exterior plate 34 which is also preferably of U-shaped metal construction. Interior wall modules (not shown) may be formed by constructing the studs 26 and 28 to be of equal length.

Each set of the studs 26 and 28 are arranged in opposed pairs thereof and may be connected intermediate their extremities by transversely extending braces 36 to increase lateral rigidity of the module 10.

As will become later apparent, interior and exterior panels 36 and 38, respectively, may be applied to the interior and exterior faces of the module 10, and more particularly to the studs 26 and 28 in order to enclose the module and thereby form interior and exterior wall surfaces. Additionally, suitable insulation 40 may be interposed between the wall panels 36 and 38 as desired, as well as between the tubes 24 and the panels 36 and 38. Note that although the studs 26 and 28 are shown as being alternately spaced with respect to the tubes 24, the spacing of studs 26 and 28 is not dependent upon the spacing of tubes 24, consequently, the spacing of studs 26 and 28 may be varied as required so as to correspond to the width of the particular panels 36 and 38 employed, or in order to meet loading requirements.

A pair of spaced apart, elongate parallel plates 42 and 44 are interposed between upper portions of the studs 26 and 28 extending above the upper horizontal support member 12 and form, in combination with support member 12, a J-shaped elongate channel which communicates with the interior of each of the tubes 24. Upper horizontal support member 12 may be formed integral with plates 42 and 44 if desired.

The module 10 is particularly suited for carrying out an improved method of constructing a concrete building as will now be described. The first step involved in the improved construction method involves erecting one of the modules 10 on a suitable supporting surface (not shown) such as a footing or foundation. A number of modules are so erected and interconnected along their mutual lateral edges to form a continuous wall. With the wall thus erected, a floor section generally indicated at 46, is mounted on top of the wall. Typically, floor section 46 is of unitary construction and may comprise upper and lower, parallel, precast concrete planks 48 and 50 separated adjacent one end thereof by a horizontally extending wall plug 52 which is disposed between planks 48 and 50 and is spaced inwardly from the exterior extremities thereof. It may be appreciated that other conventional types of floor sections may be successfully employed including a steel joint type or a poured-in-placed reinforced concrete slab.

In any event, the outer edge of the lower plank 50 is positioned on the interior plate 32 so as to be primarily supported by studs 28. A compressible shim 54 may be interposed between the lower plank 50 and interior plate 32 if desired. With the floor section 46 thusly installed, the exterior edges of the upper and lower planks 48 and 50 are spaced inwardly from studs 26 and the outer panel 38 so as to define an elongate slot communicating with the J-shaped channel in the upper portion of each of the modules 10. Vertically extending steel reinforcement rods 56 are then inserted into the interior of tubes 24 and a single pour of flowable concrete is introduced through the longitudinal slot between the floor section 46 and studs 26 into the J-shaped channel. Concrete entering the J-shaped channel flows into the interior of tubes 24 and eventually begins to fill the bottom of the channel. As the channel is being filled, horizontal steel reinforcement rods 58 are inserted into the channel or between adjacent ones of the floor sections 46. As concrete continues to flow into the channel, the lower portion thereof between plate 42 and 44 is filled to provide a horizontally extending beam running the entire length of the wall. Finally, concrete flows into the space bounded by upper portions of the plate 44, upper and lower planks 48 and 50 and plug 52 until the upper level of concrete is flush with the upper edge of plate 42 and upper plank 48.

During the single pour of the concrete, workmen performing the pouring operation may position themselves and their equipment on the upper plank 48 so as to have convenient access to the longitudinal slot between the floor section 46 and modules 10. It may also be appreciated from the foregoing description, that a continuous volume of concrete extends through the tubes 24, J-shaped channel at the top of the modules 10 and the floor section 46, to define a continuous structural connection between these building components which is totally free of concrete joints.

At this point in the construction procedure, the single pour of concrete is allowed to set and cure in order to provide the wall and floor section 46 with the additional structural strength to support additional floors and wall thereon. In order to hasten and assure complete effective curing of the concrete during cold weather, heat is applied to the modules 10 preferably from the interior side thereof. Recalling now that the entire wall of one storey of the building as well as the floor thereabove have already been constructed, it may be appreciated that an enclosure 60 defined by the module 10 and floor section 46 is provided within which heat may be introduced by any suitable means in order to warm the freshly poured concrete within each of the modules 10. By virtue of the enclosure 60, the air warmed adjacent the interior sides of the modules 10 is prevented from escaping into the atmosphere; consequently, less energy is needed to impart the desired amount of heat to the concrete. Moreover, since all of the air within the enclosure 60 is at approximately the same temperature, heat is applied essentially uniformly to all of the modules 10 in a manner which avoids "cold spots" and may be easily controlled with regard to temperature.

After the concrete has been cured, another module 10*a* and associated floor section (not shown) may be mounted on top of module 10 and floor section 46 in the manner previously described in order to construct additional storeys of the building. Insulation 40 may be installed within the modules 10 and 10*a*, and the wall panels 36 and 38 may then be secured directly to the studs 26 and 28.

In view of the foregoing it is apparent that the wall module 10 comprises an inner structural core consisting of concrete and a surrounding structural grid which initially serves to support a floor mounted thereonabove but later serves only to provide framework to which exterior and interior wall panels may be applied. Additionally, it may be appreciated that a method of constructing a cast-in-place concrete structure is disclosed using prefabricated wall modules which comprises the steps of: erecting the wall module to form a wall; placing a floor on top of the wall; supporting the floor using the wall; and, then, introducing flowable concrete simultaneously into the wall module and into the floor to form a continuous concrete connection between the wall and the floor. Further, it is apparent that the step of supporting the floor using the wall is carried out by positioning a plurality of vertically extending support studs in weight bearing relationship between a supporting surface and an edge of the floor section. Thus, it is clear that the method of construction described above not only provides for the reliable accomplishment of the objects of the invention but does so in a particularly effective and economical manner.

CLAIMS

1. A wall module for use in building concrete structures, comprising:

a plurality of rigid elongate tubes disposed in spaced, parallel relationship to each other;

a first elongate frame member extending transverse to the longitudinal axes of said tubes and connected to one end of each of said tubes;

a second elongate frame member extending transverse to the longitudinal axes of said tubes and connected to the other end of each of said tubes; and

a plurality of vertical support members disposed in spaced, parallel relationship to each other and each connected to said first and second frame members, said vertical support members being laterally spaced from said tubes and including portions extending beyond said one end of said tubes.

2. A module as claimed in Claim 1, wherein said vertical support members are arranged in first and second aligned, opposed sets thereof on opposite sides of said tubes, said module further including means extending transversely between said portions of said members in said first and second set thereof for forming a pair of opposed walls and defining in combination with said first frame member a channel ommunicating with the interior of each of said tubes.

3. A module as claimed in Claim 2, wherein the vertical support members in said first and second aligned sets thereof arranged in opposing pairs, the opposing pairs of said support elements being alternately arranged between said tubes with one of said pairs between each pair of adjacent tubes.

4. A module as claimed in Claim 2 or 3, including a brace joining the support members in at least certain of said opposing pairs thereof.

5. A module as claimed in any one of Claims 2 to 4, wherein said portions of said vertical support members in said first set thereof are longer than the portions of said support members in said second set thereof whereby to define a notch in said module adapted for complementally receiving the

edge of a floor therewithin whereby the support members in said second set thereof support the weight of said floor.

6. A method of constructing a cast-in-place concrete structure using prefabricated wall modules of the type having vertical voids and a horizontally extending channel along the top thereof, said voids and said channel being adapted to receive concrete therein, said structure further including a floor section having a horizontally extending space therein communicating with said module channel, comprising the steps of:

(A) erecting at least one of said wall modules;

(B) then, placing said floor section on top of an upper horizontal edge of said one wall module;

(C) supporting the weight of said floor section using said one wall module; and

(D) then, introducing flowable concrete substantially simultaneously into said vertical voids, said channel and said horizontally extending space whereby to form vertical concrete supports in said wall module and a continuous concrete connection between said wall module and said floor section.

7. A method as claimed in Claim 6, including the step of erecting, after step (D) has been performed, another wall module on top of said floor section.

8. A method as claimed in Claim 6, wherein steps (A), (B), (C) and (D) are repeatedly performed to construct a multi-storey structure.

9. A method as claimed in any of Claims 6 to 8, wherein step (D) is performed by pouring said concrete through an elongate slot between one edge of said floor section and one side of said one wall module.

10. A method as claimed in any of Claims 6 to 9, including the step of curing the introduced concrete by introducing heat into the interior of said structure defined by each erected wall module and floor section.

11. A method as claimed in any of Claims 6 to 10, wherein step (C) is performed by positioning a vertical stud in said one wall module in weight bearing relationship between a supporting surface and an edge of said floor section.

12. A method as claimed in any of Claims 6 to 11, wherein steps (A), (B) and (C) are performed repeatedly before step (D) to form a plurality of walls supporting a continuous floor thereabove.

13. A structure when produced by the method as claimed in any of Claims 6 to 12.

14. A wall module substantially as hereinbefore described with reference to the accompanying drawings.

15. A method of constructing a cast-in-place concrete structure, substantially as hereinbefore described with reference to the accompanying drawings.

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